

School of Sciences and Engineering

CSCE 2303– Computer Organization and Assembly Language Programming

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Project II: Memory Hierarchy Simulator

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Description of the implementation

1. Struct Cache

We used a struct to hold the attributes of the Cache such as the total cache size S, the cache line size L, and the number of cycles needed to access the cache. There are also some other attributes like:

- 1. Hit and miss (They used to keep track of the number of the hit and miss times)
- 2. Count (It is used to keep track of the number of accesses)
- 3. isHit (It is a boolean value to check whether it is hit or miss)
- 4. vector<int> sequence (A vector to store the sequences after reading them from the access sequence text file imputed by the user)
- 5. vector<long>index (It is used to store the indices)
- 6. vector
bool> valid (It is used to store if it is valid or not)
- 7. vector <pair<int, int> >cacheContent; (It is used to hold the tag and the content of the cache)

There are also other features but they are made for the bonus case which is supporting separate caches for instructions and data such as,

- 1. vector<char> seqCheck (It is used to know if it's Instanous or Data)
- 2. vector<pair<int, int>> cacheInst; (It is used to store the tag, instantaneous content)
- 3. vector<pair<int, int>> cacheData; (It is used to store the tag and data content)
- 4. vector
bool> validInst (It is used to store the valid of instantaneous)
- 5. vector
bool> validData (It is used to store the valid of data)
- 6. int instS (To store the total cache size S of the instantaneous)
- 7. int dataS; (To store the total cache size S of the data)

2. Map Memory

We used a map for the memory. The first value is the address and the second is the content.

Important Functions:

1. Read

It is a function that is used to read any of the text files only by sending the name of the text file entered by the user like "memory.txt". Also, it gets the integer which accordingly read a specific file. For example, 0 is to read the memory file, 1 is to read the Address Sequence file, and 2 is to read the labeled address sequence.

2. Print Output

It is used to print the output whether it is for the labeled case or the original case and it does so according to a boolean value passed to it.

3. Split Sequence:

It iterates over the sequence vector to split the sequence and get the index, tag, and validity. It calls the print function output each iteration.

Bonus Features

We did one bonus which is supporting separate caches for instructions and data. In this case, each of the memory addresses in the provided sequence must be labeled as either an instruction or data access

Design Decisions and Assumptions

We assumed that the user will enter the name of the text files in the directory of the project. So, the user will enter only the name such as "memory.txt", not the directory of the file.

Bugs or Issues

There are no known bugs or issues with our code.

User Guide

The user will be doing the following steps in the same order:

- 1. The user will first enter the name of the memory text file.
- 2. He will enter the name of the address sequence text file.

- 3. He will enter 1 if the sequence file is labeled and 0 if it is not.
- 4. He will enter the total cache size.
- 5. He will enter the cache line size.
- 6. He will enter the number of cycles needed to access the cache.

```
Microsoft Visual Studio Debug Console

Please, Enter the memory file name
memory.txt

Please, enter the Sequence File Name
Address_Sequence.txt

Please, enter 1 if the sequence file is labled, or 0 if it is not
0

Please, enter the total cache size S
8

Please, enter the cache line size L
32

Please, enter the number of cycles needed to access the cache
5
```

Example with screenshots

The following screenshots show the output of the following inputs

```
Microsoft Visual Studio Debug Console
```

```
Please, Enter the memory file name
memory.txt

Please, enter the Sequence File Name
Address_Sequence.txt

Please, enter 1 if the sequence file is labled, or 0 if it is not
0

Please, enter the total cache size S
16

Please, enter the cache line size L
32

Please, enter the number of cycles needed to access the cache
5
```

The Sequence List used in this example:

1011011

1101011

1011000

1101010

1000011

0001101

1000000

1001000

The output:

```
idx: 1011011 16
This is a miss
      Valid
              Tag
Index
                                            Content
0000
       0
              000000000000000000000000
                                            00000
0001
                                           00000
       0
              00000000000000000000000
0010
      0
              00000000000000000000000
                                           00000
0011 0
              0000000000000000000000
                                           00000
0100
    0
            000000000000000000000
                                           00000
0101
    0
             0000000000000000000000
                                           00000
0110
      0
              00000000000000000000000
                                           00000
0111
      0
              00000000000000000000000
                                           00000
1000
     0
              00000000000000000000000
                                           00000
1001 0
             00000000000000000000000
                                           00000
1010 0
             0000000000000000000000
                                           00000
1011
             000000000000000000000101
                                           00017
      1
1100
              00000000000000000000000
                                           00000
1101
      0
              00000000000000000000000
                                           00000
1110
      0
              00000
1111
       0
              00000000000000000000000
                                           00000
Total number of accesses: 1
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
```

```
idx: 1101011 16
This is a miss
Index
      Valid
                                        Content
0000
      0
             00000
0001
      0
             00000000000000000000000
                                        00000
0010
     0
             00000
0011
      0
             00000000000000000000000
                                        00000
0100
      0
             00000000000000000000000
                                        00000
0101
             00000000000000000000000
                                        00000
      0
             00000000000000000000000
0110
      0
                                        00000
                                        00000
0111
    0
             000000000000000000000000
1000
    0
             00000000000000000000000
                                        00000
1001
      0
            00000000000000000000000
                                        00000
1010
             00000000000000000000000
      0
                                        00000
             00000000000000000000110
1011
      1
                                        00018
1100 0
             00000000000000000000000
                                        00000
1101 0
             00000000000000000000000
                                        00000
1110
    0
             00000000000000000000000
                                        00000
1111
      0
             00000000000000000000000
                                        00000
Total number of accesses: 2
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
```

```
idx: 1101010 16
This is a miss
Index
      Valid Tag
                                        Content
9999
      0
             0000000000000000000000
                                        00000
0001
      0
                                        00000
             00000000000000000000000
0010
      0
             00000000000000000000000
                                        00000
    0
0011
             00000000000000000000000
                                        00000
0100
    0
             00000000000000000000000
                                        00000
0101
    0
             00000000000000000000000
                                        00000
0110
             00000000000000000000000
      0
                                        00000
0111
             0
                                        00000
             000000000000000000000101
1000
      1
                                        00019
1001
    0
             00000000000000000000000
                                        00000
1010
    1
             000000000000000000000110
                                        00020
1011
             000000000000000000000110
                                        00018
     1
1100
      0
             99999
1101
      0
             000000000000000000000000
                                        00000
1110
      0
             00000000000000000000000
                                        00000
1111
      0
             0000000000000000000000
                                        00000
Total number of accesses: 4
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
______
```

```
_____
idx: 1101010 16
This is a miss
Index Valid
            Tag
                                       Content
0000
      0
            00000000000000000000000
                                       00000
0001
            00000
0010
     0
            00000
0011
     0
            0000000000000000000000
                                       00000
0100
     0
            0000000000000000000000
                                       00000
0101
     0
            00000
0110
            00000000000000000000000
      0
                                       00000
0111
     0
            00000000000000000000000
                                       00000
1000
     1
            000000000000000000000101
                                       00019
1001
      0
            000000000000000000000000
                                       00000
     1
1010
           00000000000000000000110
                                       00020
1011
     1
            000000000000000000000110
                                       00018
1100
     0
            00000000000000000000000
                                       00000
1101
     0
            00000000000000000000000
                                       00000
1110
            00000000000000000000000
                                       00000
1111
     0
            00000000000000000000000
                                       00000
Total number of accesses: 4
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
```

```
idx: 1000011 16
This is a miss
Index Valid Tag
                                      Content
0000
     0
            00000000000000000000000
                                      00000
0001
     0
            00000
0010
    0
           0000000000000000000000
                                      00000
0011
           00021
0100
           0000000000000000000000
                                      00000
    0
0101
     0
           0000000000000000000000
                                      00000
0110
     0
           00000000000000000000000
                                      00000
0111
      0
           00000
1000
     1
           000000000000000000000101
                                      00019
           1001
     0
                                      00000
1010
                                      00020
            00000000000000000000110
     1
1011
            00000000000000000000110
     1
                                      00018
1100
            0000000000000000000000
                                      00000
     0
1101
            0
                                     00000
1110
            00000000000000000000000
                                     00000
1111
      0
            00000
Total number of accesses: 5
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
```

```
idx: 1101 16
This is a miss
Index Valid
                                    Content
            Tag
0000
     0
            00000000000000000000000
                                    00000
0001
     0
                                    00000
            00000000000000000000000
0010
     0
            00000000000000000000000
                                    00000
0011
     1
            00021
0100
     0
            00000000000000000000000
                                    00000
0101
     0
            00000
0110
     0
            00000000000000000000000
                                    00000
0111
     0
            00000
1000
     1
            00019
1001
            00000000000000000000000
     0
                                    00000
1010
                                    00020
    1
            00000000000000000000110
1011
     1
            00000000000000000000110
                                    00018
1100
     0
            00000
     1
1101
            00000000000000000000000
                                    00022
1110
     0
            00000
1111
            00000
Total number of accesses: 6
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
```

	*				
	00000 16				
This is	a miss				
Index	V-1:-	T	Contont		
	Valid	Tag	Content		
	1	0000000000000000000100	00023		
		0000000000000000000000	99999		
0010	0	0000000000000000000000	00000		
0011	1	000000000000000000000000000000000000000	00021		
0100	0	000000000000000000000	00000		
0101	0	000000000000000000000	00000		
0110	0	000000000000000000000	00000		
0111	0	0000000000000000000000	00000		
1000	1	000000000000000000000000101	00019		
1001	0	0000000000000000000000	00000		
1010	1	0000000000000000000110	00020		
1011	1	00000000000000000000110	00018		
1100	0	0000000000000000000000	00000		
1101	1	000000000000000000000	00022		
1110	0	000000000000000000000	00000		
1111	0	000000000000000000000	00000		
Total number of accesses: 7					
Miss ratio= 1					
Hit ratio= 0					
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105					

```
idx: 1001000 16
This is a miss
Index Valid Tag
                                        Content
0000
      1
             00023
0001
      0
             00000
0010
    0
            00000000000000000000000
                                       00000
0011 1
            000000000000000000000100
                                       00021
0100 0
           00000000000000000000000
                                        00000
0101 0
           00000000000000000000000
                                       00000
           0000000000000000000000
0110
                                       00000
    0
           00000000000000000000000
0111
                                       00000
1000 1
           000000000000000000000100
                                       00024
1001 0
           00000000000000000000000
                                       00000
1010 1
           000000000000000000000110
                                       00020
1011
           000000000000000000000110
    1
                                       00018
    0
           0000000000000000000000
1100
                                       00000
1101 1
           00000000000000000000000
                                       00022
1110 0
            0000000000000000000000
                                       00000
1111 0
             00000000000000000000000
                                        00000
Total number of accesses: 8
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
```

nis 19	s a miss			
Index	Valid	Tag	Content	
9999	1	000000000000000000000100	00023	
9001	0	0000000000000000000000	00000	
9010	0	0000000000000000000000	00000	
9011	1	000000000000000000000100	00021	
9100	0	0000000000000000000000	99999	
9101	0	0000000000000000000000	00000	
9110	0	0000000000000000000000	00000	
9111	1	000000000000000000000100	00025	
1000	1	000000000000000000000100	00024	
1001	0	00000000000000000000000	00000	
1010	1	00000000000000000000110	00020	
1011	1	00000000000000000000110	00018	
1100	0	0000000000000000000000	00000	
1101	1	0000000000000000000000	00022	
1110	0	0000000000000000000000	99999	
1111	0	0000000000000000000000	00000	
Total r	number o	f accesses: 9		
Miss ratio= 1				
Hit ratio= 0				

```
idx: 100 16
This is a miss
Index
      Valid
                                         Content
9999
      1
             00023
0001
      0
             00000
9919
      0
             0000000000000000000000
                                         00000
9911
      1
             00021
9100
      1
             00000000000000000000000
                                         00026
0101
             00000
      0
9110
      0
             00000000000000000000000
                                         00000
9111
      1
             00025
1000
     1
             00000000000000000000100
                                         00024
                                         00000
1001
      0
             00000000000000000000000
1010
     1
             00000000000000000000110
                                         00020
1011
      1
             000000000000000000000110
                                         00018
1100
             00000000000000000000000
                                         00000
      0
1101
      1
             00000000000000000000000
                                         00022
1110
      0
             00000000000000000000000
                                         00000
1111
      0
             0000000000000000000000
                                         00000
Total number of accesses: 10
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
```

	01000 16		
his i	s a miss		
Index	Valid	Tag	Content
9000	1	000000000000000000000100	00023
9001	0	0000000000000000000000	00000
9010	0	0000000000000000000000	99999
9011	1	000000000000000000000000000000000000000	00021
9100	1	0000000000000000000000	00026
91 01	0	0000000000000000000000	00000
9110	0	0000000000000000000000	00000
2111	1	000000000000000000000000000000000000000	00025
1000	1	000000000000000000000000000000000000000	00027
1001	0	0000000000000000000000	00000
1010	1	000000000000000000000110	00020
1011	1	00000000000000000000110	00018
1100	0	00000000000000000000000	00000
1101	1	0000000000000000000000	00022
1110	0	0000000000000000000000	00000
1111	0	0000000000000000000000	00000
Total	number of	accesses: 11	
Miss r	atio= 1		
Hit ra	tio= 0		
The Av	erage Men	nory Access Time(AMAT) of the	<pre>memory hierarchy(in cycles)= 105</pre>

```
idx: 1011011 16
This is a miss
Index
     Valid Tag
                                      Content
0000
     1
            00023
0001
    0
            00000
0010
    0
           00000000000000000000000
                                     00000
0011
    1
           00021
0100
           0000000000000000000000
                                     00026
     1
     9
0101
          0000000000000000000000
                                     00000
           00000000000000000000000
0110 0
                                     00000
0111 1
           000000000000000000000100
                                     00025
1000 1
           00027
1001
    0
            00000000000000000000000
                                     00000
1010
            00000000000000000000110
                                     00020
1011
           000000000000000000000101
                                     00017
1100 0
           00000000000000000000000
                                     00000
1101 1
           00000000000000000000000
                                     00022
1110 0
            00000000000000000000000
                                     00000
1111 0
            00000000000000000000000
                                     00000
Total number of accesses: 12
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
```

```
idx: 1101011 16
This is a miss
Index Valid
            Tag
                                     Content
0000
     1
            00023
0001
     0
                                     00000
            00000000000000000000000
0010
     0
                                     00000
            000000000000000000000000
     1
0011
          00021
0100
     1
           0000000000000000000000
                                     00026
0101
     0
            000000000000000000000000
                                     00000
0110
     0
            00000000000000000000000
                                     00000
0111
     1
            00025
1000
     1
           00027
1001
     0
           00000000000000000000000
                                     00000
1010 1
           000000000000000000000110
                                     00020
1011
     1
           00000000000000000000110
                                     00018
1100
     0
            00000000000000000000000
                                     00000
1101
     1
            00000000000000000000000
                                     00022
1110
     0
            000000000000000000000000
                                     00000
1111
     0
            00000
Total number of accesses: 13
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
```

idx:				
This	ıs a	hit		
Inde	ς V	/alid	Tag	Content
0000	1		000000000000000000000000000000000000000	00023
0001	9)	0000000000000000000000	99999
0010	9)	0000000000000000000000	99999
0011	1		000000000000000000000000000000000000000	00021
0100	1		000000000000000000000	00026
0101	0)	000000000000000000000	00000
0110	0)	000000000000000000000	00000
0111	1		000000000000000000000000000000000000000	00025
1000	1		000000000000000000000000000000000000000	00027
1001	0)	000000000000000000000	00000
1010	1		0000000000000000000110	00020
1011	1		0000000000000000000110	00018
1100	0)	000000000000000000000	00000
1101	1		000000000000000000000	00022
1110	0)	000000000000000000000	00000
1111	0)	000000000000000000000	00000
Total number of accesses: 14				
Miss ratio= 0.928571				
Hit ratio= 0.0714286				
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 97.8571				

```
idx: 1000000 16
This is a hit
      Valid
Index
                                          Content
0000
              00023
0001
      0
             00000000000000000000000
                                          00000
0010
      0
             00000000000000000000000
                                          00000
            0011
                                          00021
      1
0100
      1
            00000000000000000000000
                                          00026
0101
     0
            0000000000000000000000
                                          00000
0110
      0
            00000000000000000000000
                                          00000
0111
            000000000000000000000100
                                          00025
1000
     1
            00027
1001
      0
             00000000000000000000000
                                          00000
1010
     1
             00000000000000000000110
                                          00020
             00000000000000000000110
1011
     1
                                          00018
1100
     0
            00000000000000000000000
                                          00000
1101
            00000000000000000000000
                                          00022
     0
1110
            00000000000000000000000
                                          00000
1111
      0
             0000000000000000000000
                                          00000
Total number of accesses: 15
Miss ratio= 0.866667
Hit ratio= 0.133333
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 91.6667
```

idx: 1001000 16					
This is a miss					
Index Valid Tag Content					
0000 1 00000000000000000000000000000000					
0001 0 000000000000000000000000000 00000					
0010 0 000000000000000000000000000 00000					
0011 1 00000000000000000000000000000000					
0100 1 00000000000000000000000000000000					
0101 0 00000000000000000000000000000000					
0110 0 000000000000000000000000000 00000					
0111 1 00000000000000000000000000000000					
1000 1 00000000000000000000000000000000					
1001 0 000000000000000000000000000 00000					
1010 1 00000000000000000000000000000000					
1011 1 00000000000000000000000000000000					
1100 0 000000000000000000000000000 000000					
1101 1 00000000000000000000000000 00022					
1110 0 0000000000000000000000000 000000					
1111 0 00000000000000000000000000000000					
Total number of accesses: 16					
Miss ratio= 0.875					
Hit ratio= 0.125					
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 92.5					